



Nuclear Energy

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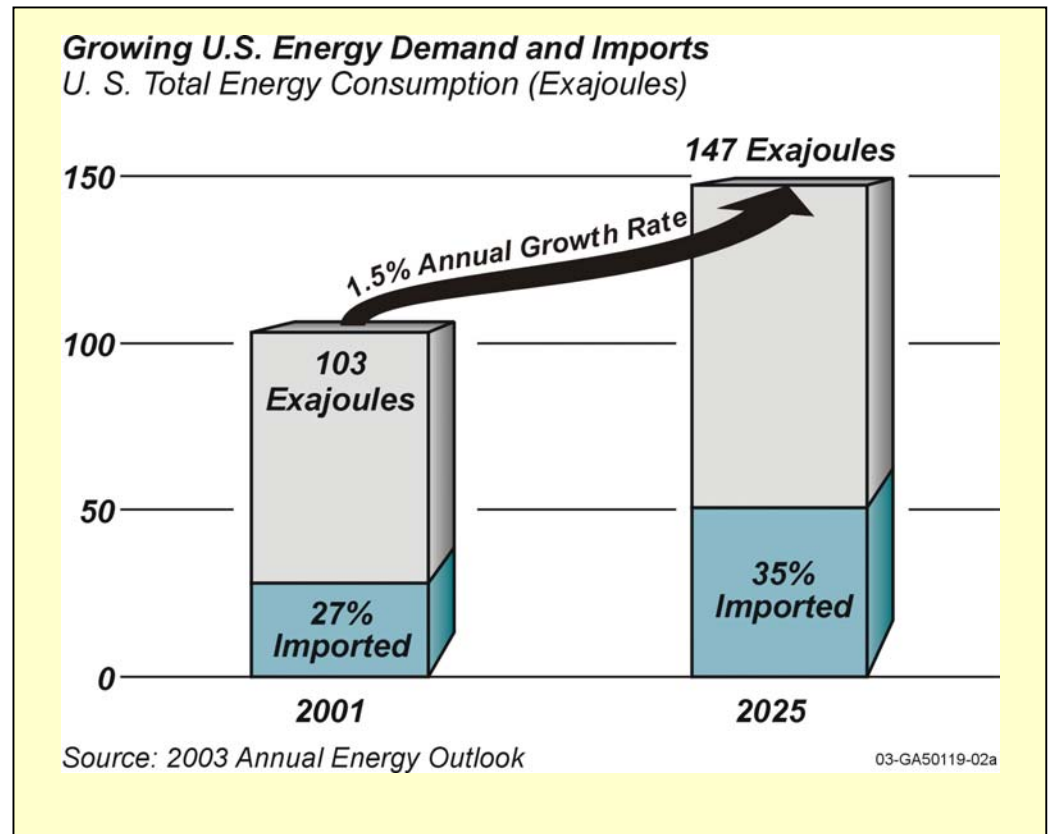
***Director
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***Energy Options for the Future
March 11-12, 2004***

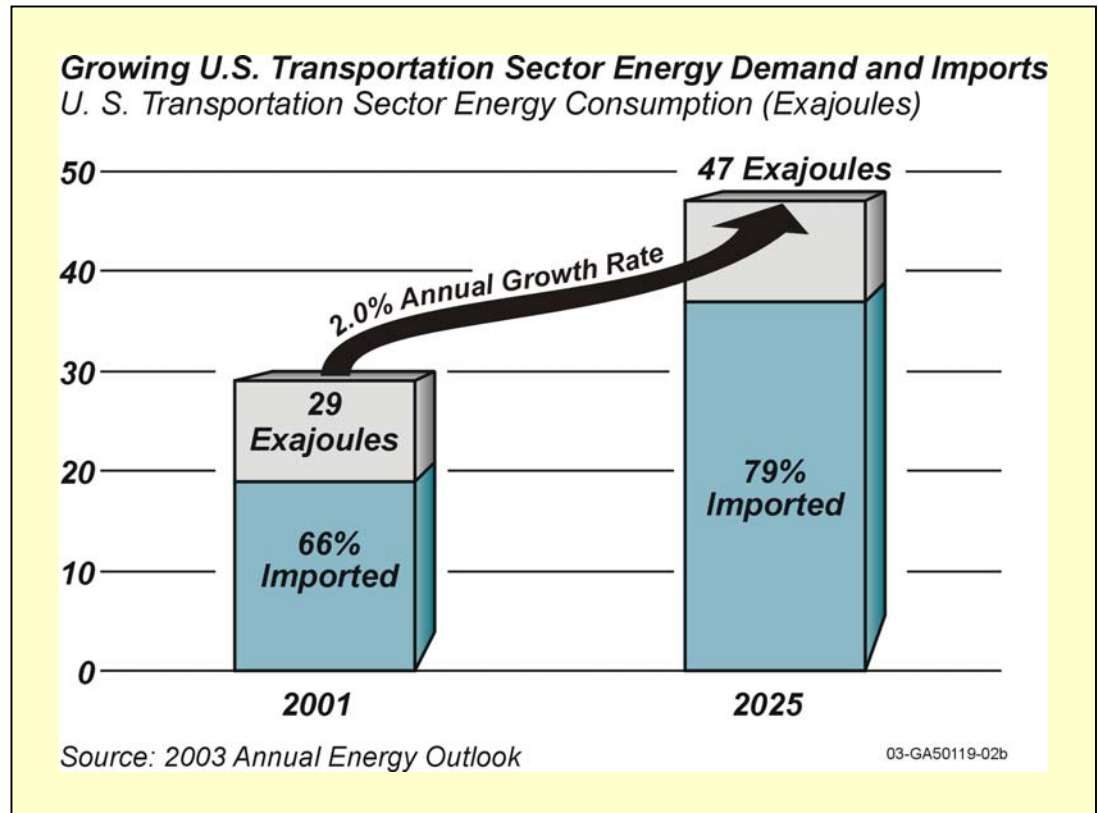
Forecast for Energy Growth

- **Annual outlook is 1.5% growth in U.S. energy to 2025**
- **Most growth is in natural gas and coal**
- **Imports will increase**
- **Nuclear can contribute if deployed in the near-term, but waste will become a major issue for significant growth**

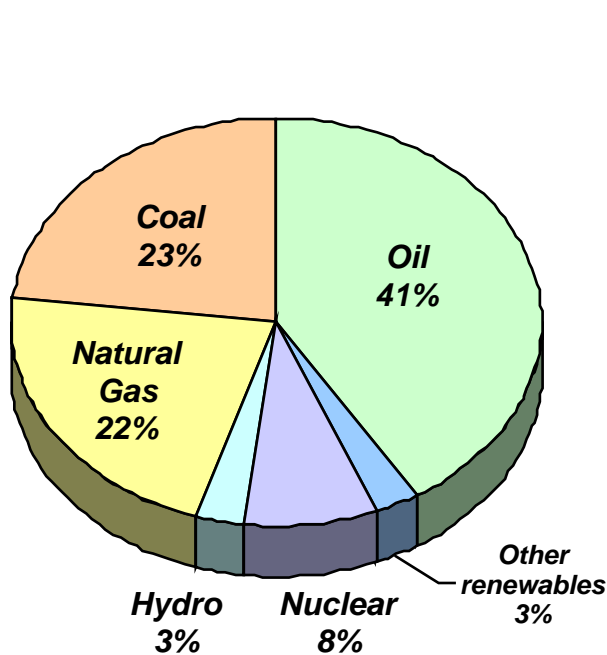


Potential for Nuclear in Transportation

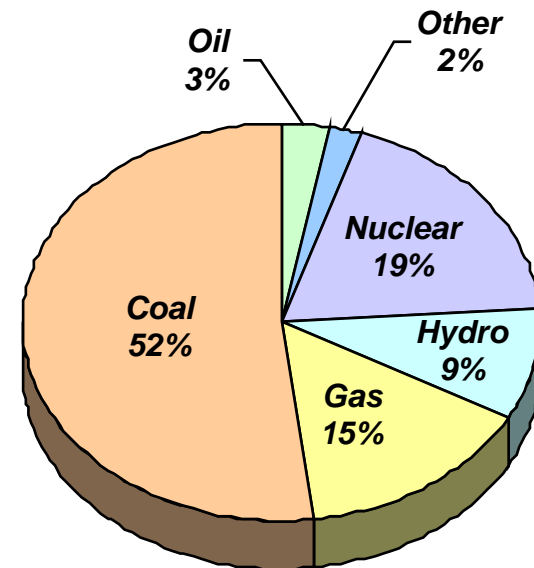
- **Transportation sector growth leads electricity & heating**
- **Outlook is for a disproportionate increase in imports**
- **Increasing dependence on imports clouds the outlook for energy security and stability**
- **Hydrogen can contribute if production-distribution-end use issues can be successfully addressed**



Why Nuclear Energy?... we depend on it today



Energy Production

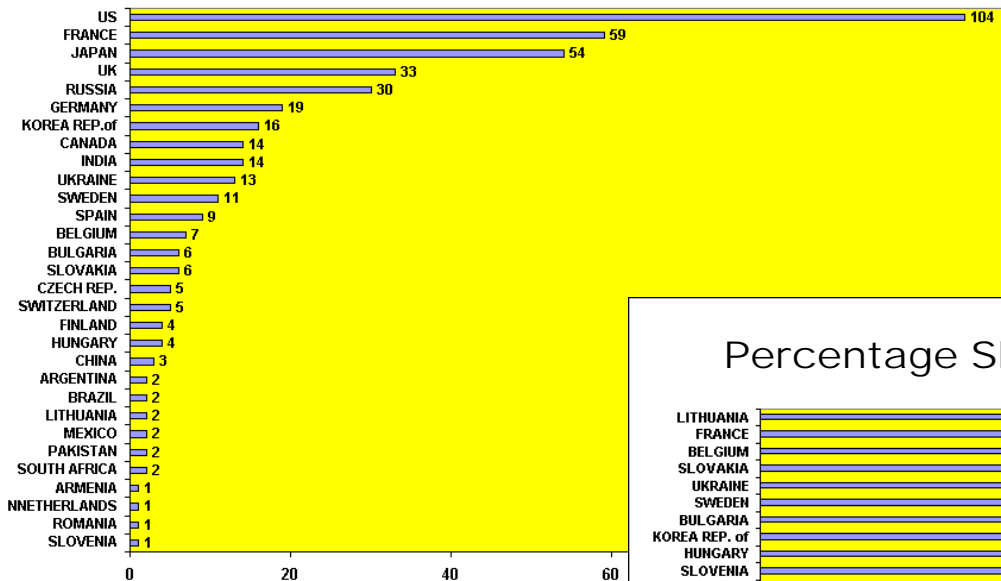


Source: EIA

U.S. Electricity Production

Nuclear Power: Critical to Many Countries

Number of Reactors in Operation

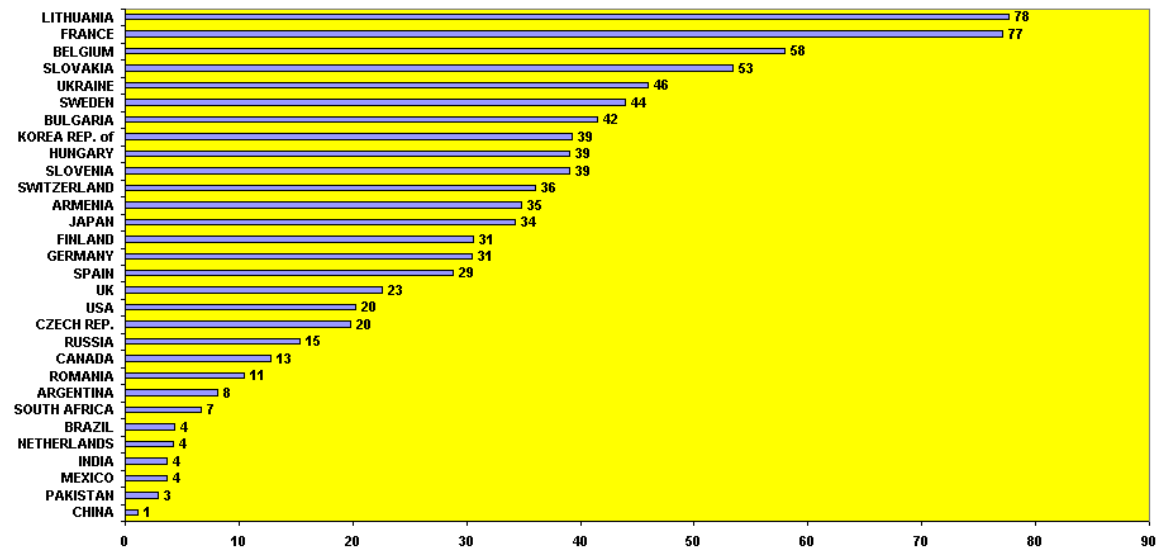


Source: IAEA Power Reactor Information System

- Worldwide, 31 countries are operating 438 nuclear plants for electricity generation
 - Total net installed capacity of 353 GWe

- Half of the world's power reactors are in the U.S., France, and Japan

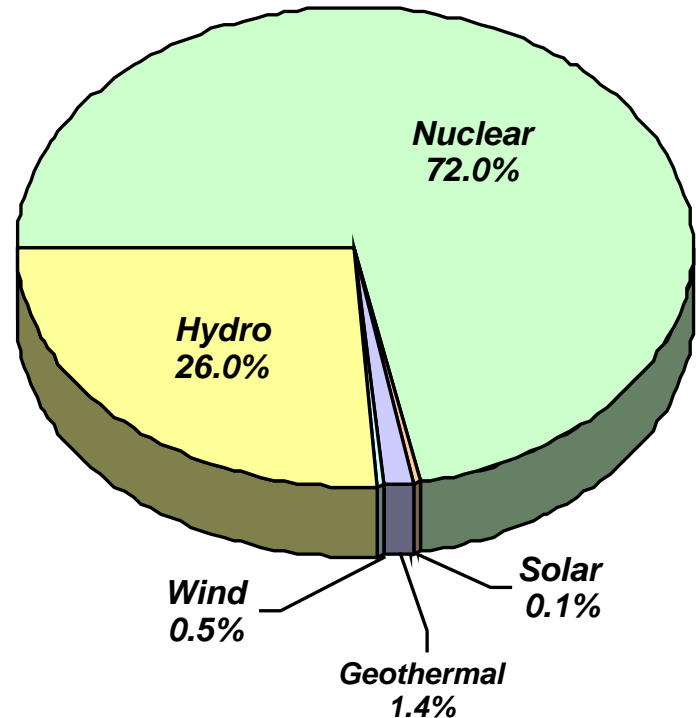
Percentage Share in Electricity Generation in 2001



Source: IAEA Power Reactor Information System

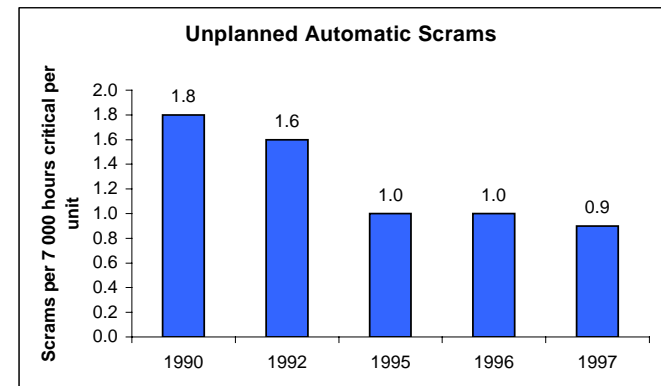
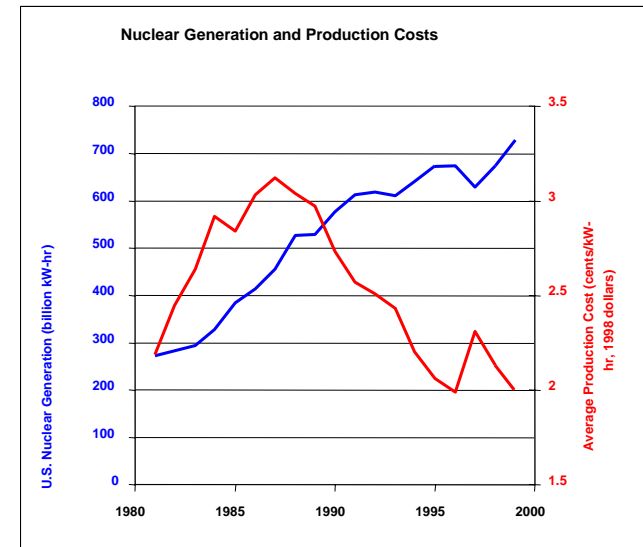
Nuclear Power is Helping Today

- **Cleaner air**
 - Emission-free generating sources supply almost 30 percent of America's electricity
 - Nuclear energy provides the greatest share of clean energy – almost three quarters

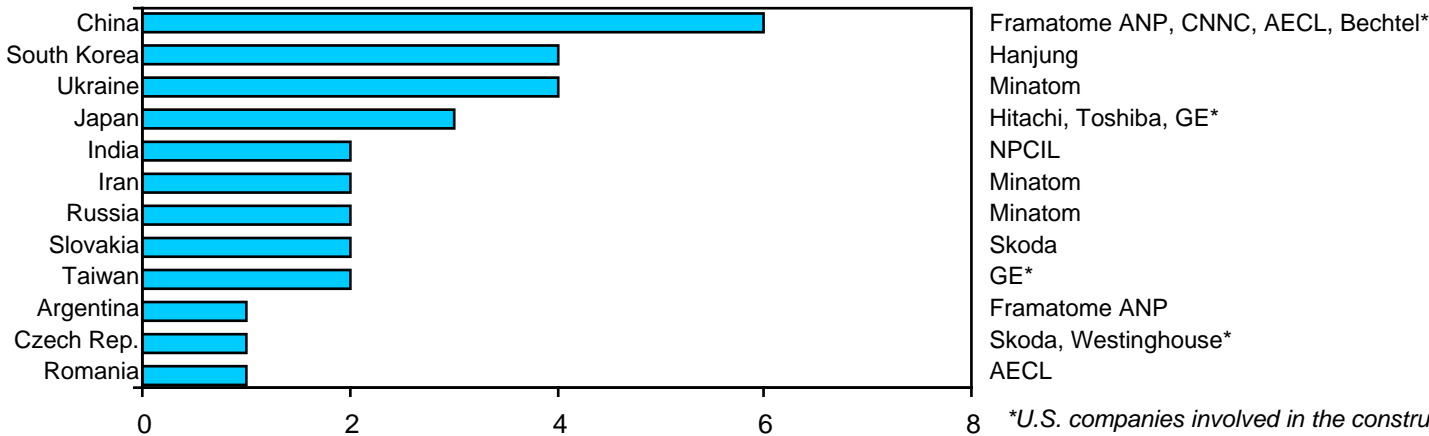


The Nuclear “Paradigm” Has Changed

- *Industry has become economically competitive*
- *Substantial improvement in safety performance*
- *Growing public acceptance*
- *“Zero” emissions technology*
- *Energy security and environmental quality suggest nuclear energy for future growth*



Several Countries Have Nuclear Power Plants Under Construction



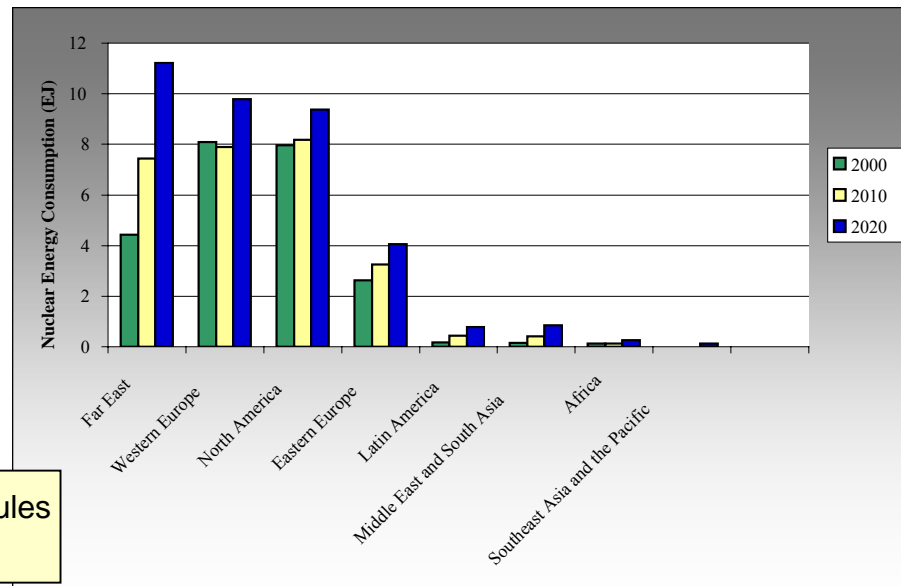
Source: IAEA Power Reactor Information System

*U.S. companies involved in the construction or providing major NSSS components

- In 12 Countries, 30 New Nuclear Plants Are Under Construction
- No nuclear plants under construction or on order in the U.S., but American power companies are actively evaluating the economic and regulatory risks

Nuclear Energy Consumption is shown in exajoules (EJ). 1 EJ = .95 quadrillion Btu = 280 BkWh

Current and Predicted World Nuclear Energy Consumption



Source: Nuclear Energy Institute

Challenges to the Long-Term Viability of Nuclear Energy

Economics

- *Reduced costs (especially capital costs)*
- *Reduced financial risk (especially licensing/construction time)*

Safety and Reliability

- *Operations safety*
- *Protection from core damage (reduced likelihood and severity)*
- *Eliminate offsite radioactive release potential*

Sustainability

- *Efficient fuel utilization*
- *Waste minimization/management*
- *Nonproliferation*

The National Energy Policy Endorses Nuclear Energy as a Major Component of Future U.S. Energy Supplies

Existing Nuclear Plants

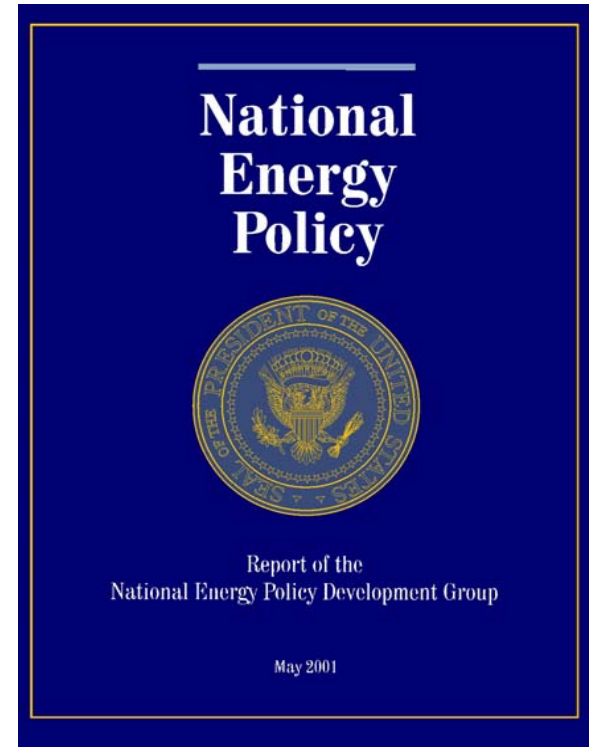
- *Expedited NRC licensing of advanced reactors*
- *Update and relicense nuclear plants*
- *Nuclear energy's role in improved air quality*
- *Geologic repository for nuclear waste*
- *Price-Anderson Act renewal*

New Nuclear Plants

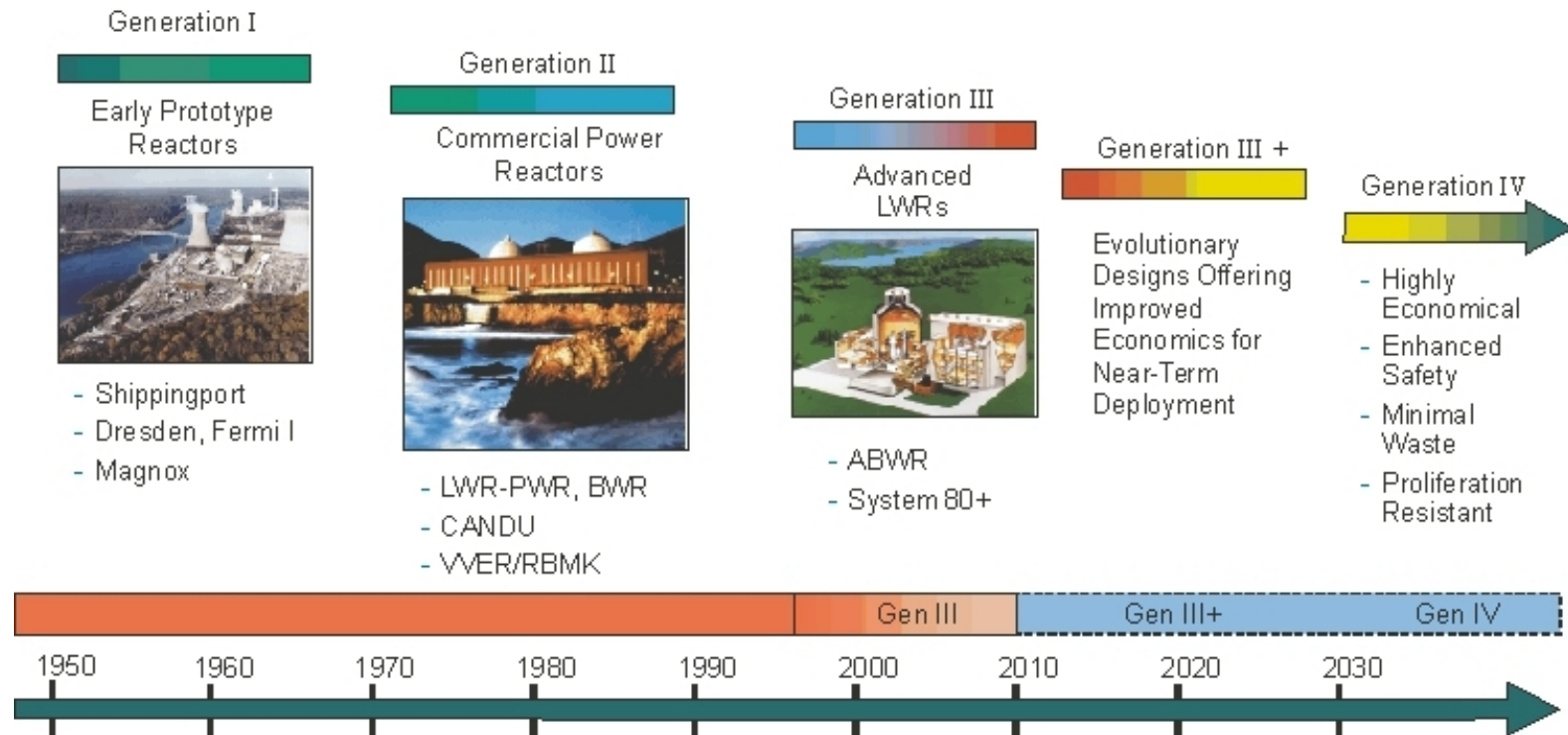
- *Advanced fuel cycle/pyroprocessing*
- *Next-generation advanced reactors*

Reprocessing

- *International collaboration*
- *Cleaner, more efficient, less waste, more proliferation-resistant*



The Generations of Nuclear Energy



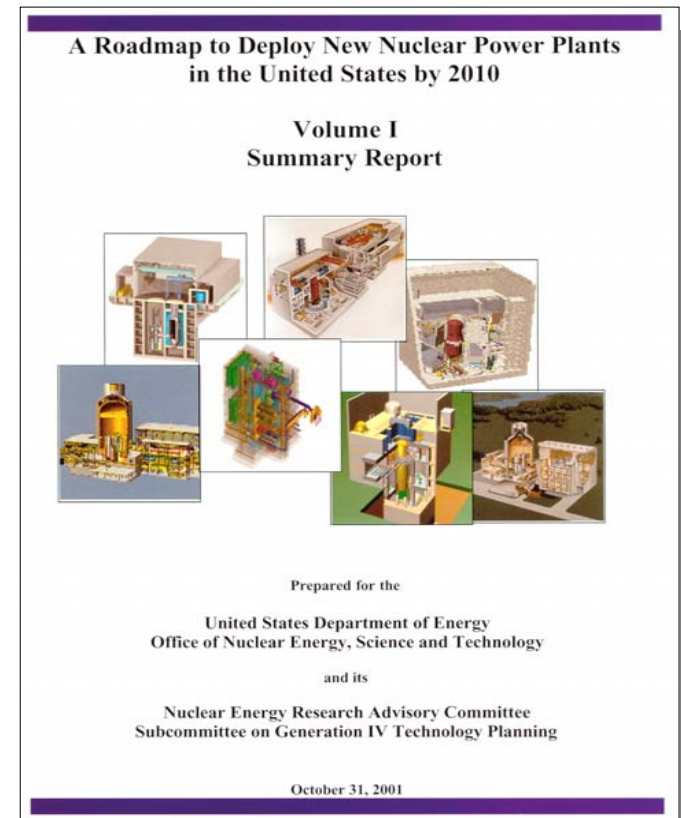
US DOE Nuclear Power 2010 and Generation IV Programs are Addressing Near-Term Regulatory and Long-Term Viability Issues

NP-2010 Program

- *Eliminate regulatory uncertainties/demonstrate 10CFR52 Process (early site permitting and a combined operating license)*
- *Complete design and engineering*
- *Construct and deploy one light-water, and one gas-cooled reactor by 2010*

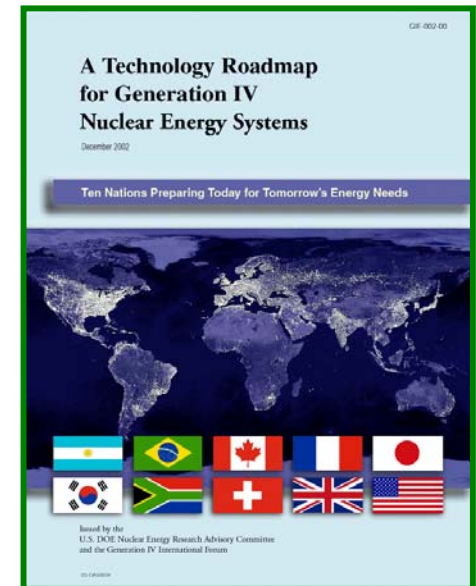
Generation IV Nuclear Energy Systems Program

- *Generation IV International Forum*
- *Concept screening and Technology Roadmap*
- *Broad spectrum of advanced system concepts*



Generation IV Technology Roadmap

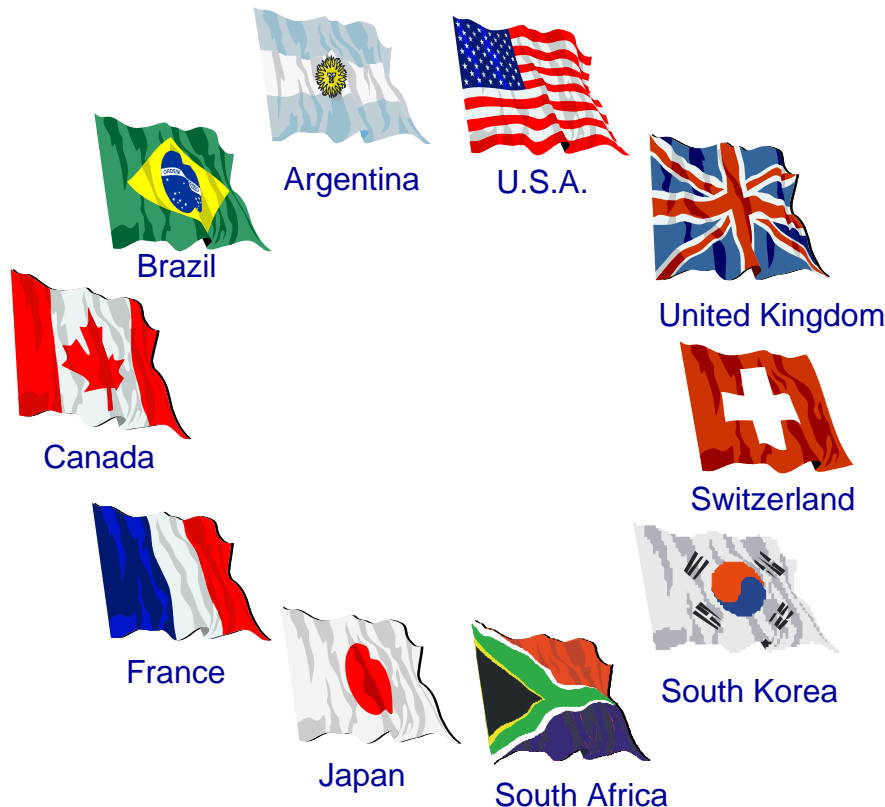
- ***Identifies systems that are deployable by 2030 or earlier***
- ***Over 100 concepts were submitted for evaluation***
- ***Six 'most promising' systems that offer significant advances towards:***
 - ***Sustainability***
 - ***Economics***
 - ***Safety and reliability***
 - ***Proliferation resistance and physical protection***
- ***Summarizes R&D activities and priorities for the systems***
- ***Lays the foundation for Generation IV R&D program plans***



<http://gif.inel.gov/roadmap>

Generation IV International Forum (GIF)

Chartered July, 2001



- **Brings international perspective:**
 - Generation IV Technology Goals
 - Evaluation of Systems and R&D
- **Endorses key elements:**
 - Six Gen IV Systems announced Sep '02
 - Generation IV Roadmap
- **Identifies areas of multilateral collaborations and establishes guidelines for collaborations**
- **Regularly reviews progress on collaborations**
- **Observers from:**
 - International Atomic Energy Agency
 - OECD/Nuclear Energy Agency
 - European Commission
 - Nuclear Regulatory Commission
 - Department of State

Highlights of System Concept Strengths

Sustainability

- *Closed cycle fast-spectrum systems*
 - *Reduced waste heat and radiotoxicity*
 - *Optimal use of repository capacity*
 - *Resource extension via regeneration of fissile material*

Safety and Reliability

- *Many concepts make good advances*

Economics

- *Water- and gas-cooled concepts*
 - *High thermal efficiency*
 - *Simplified balance of plant*
 - *Large and small plant size*

Hydrogen production and high-temperature applications

- *Very high temperature gas-, and lead alloy-cooled reactors*

Generation IV Systems

Very-High-Temperature Reactor System (safety, hydrogen production)

Lead-Cooled Fast Reactor System (sustainability, safety)

Gas-Cooled Fast Reactor System (sustainability, economics)

Supercritical-Water-Cooled Reactor System (economics)

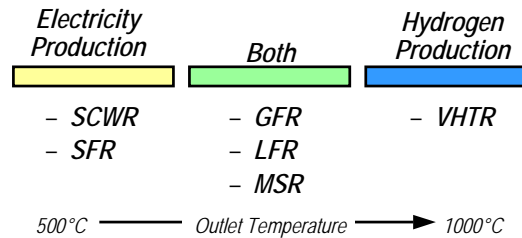
Molten Salt Reactor System (sustainability)

Sodium-Cooled Fast Reactor System (sustainability)

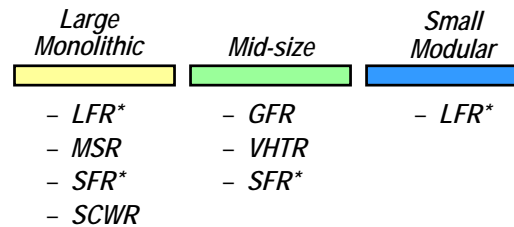
- ***Each system has R&D challenges ahead –
none are certain of success***

Generation IV System 'Portfolio'

Products

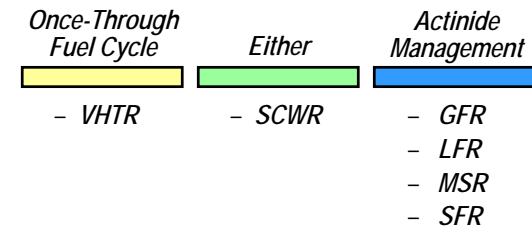


Plant Size



* Range of options

Fuel Cycle



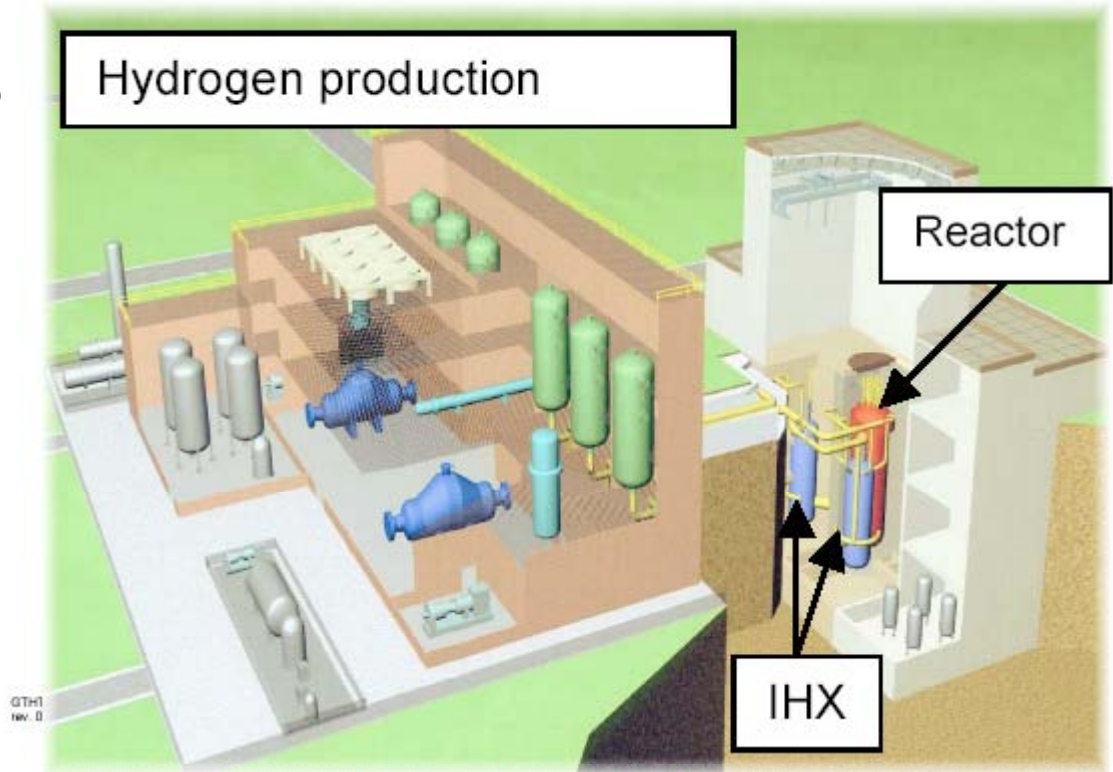
Very High-Temperature Reactor (VHTR)

Characteristics

- He coolant
- $>1000^{\circ}\text{C}$ outlet temperature
- 600 MWe
- Solid graphite block core based on GT-MHR

Benefits

- High thermal efficiency
- Hydrogen production
- Process heat applications
- High degree of passive safety

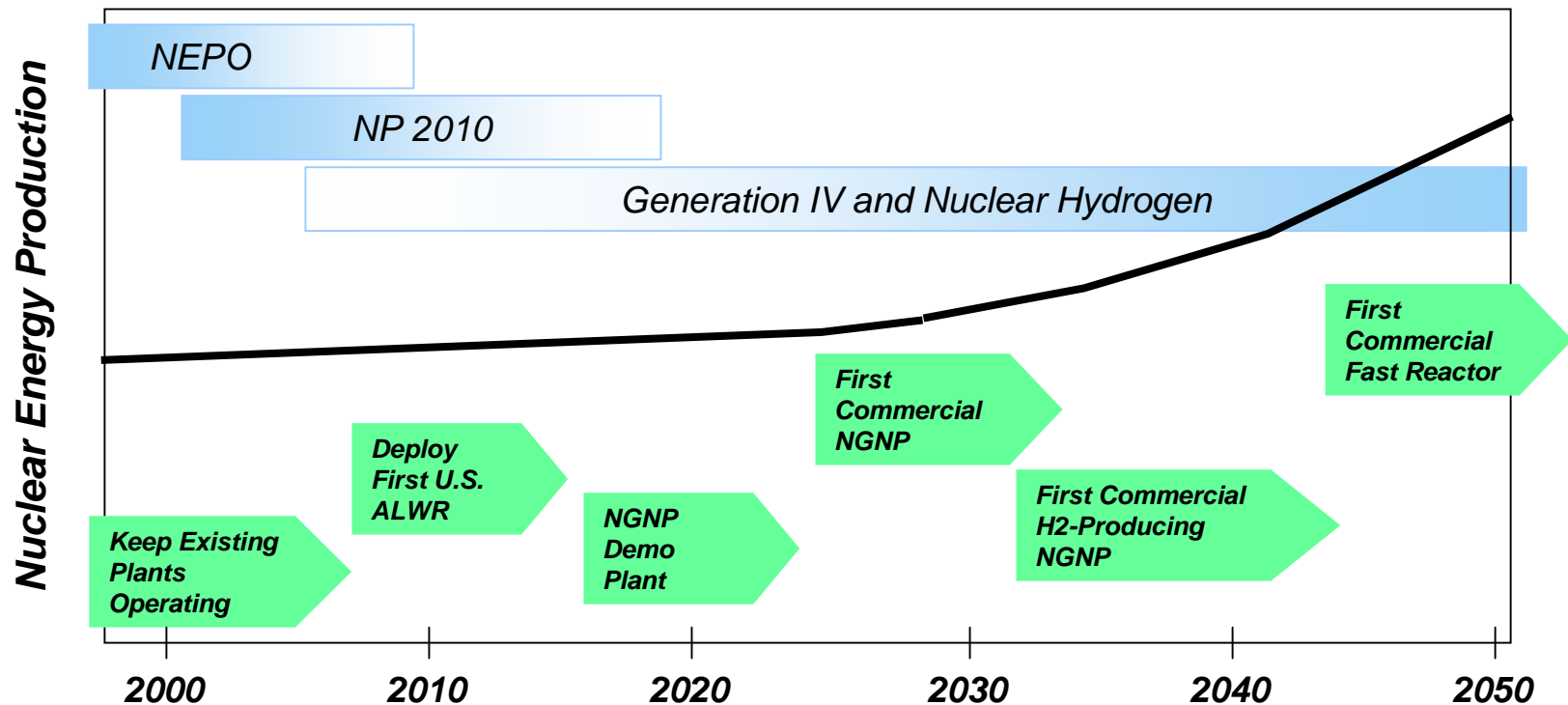


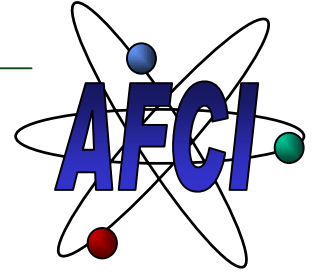
NGNP Mission Objectives

- *Demonstrate a full-scale prototype NGNP by about 2015 to 2017*
- *Demonstrate nuclear-assisted production of hydrogen (with about 10 % of the heat)*
- *Demonstrate by test the exceptional safety capabilities of the advanced gas cooled reactors*
- *Obtain an NRC License to construct and operate the NGNP, to provide a basis for future performance-based, risk-informed licensing*
- *Support the development, testing, and prototyping of hydrogen infrastructures*

Generation IV Mission in the U.S.

Developing and demonstrating advanced nuclear energy systems that meet future needs for safe, sustainable, environmentally responsible, economical, proliferation-resistant, and physically secure energy.





Advanced Fuel Cycle Initiative

The goal of the DOE NE AFCI is to implement fuel cycle technology that:

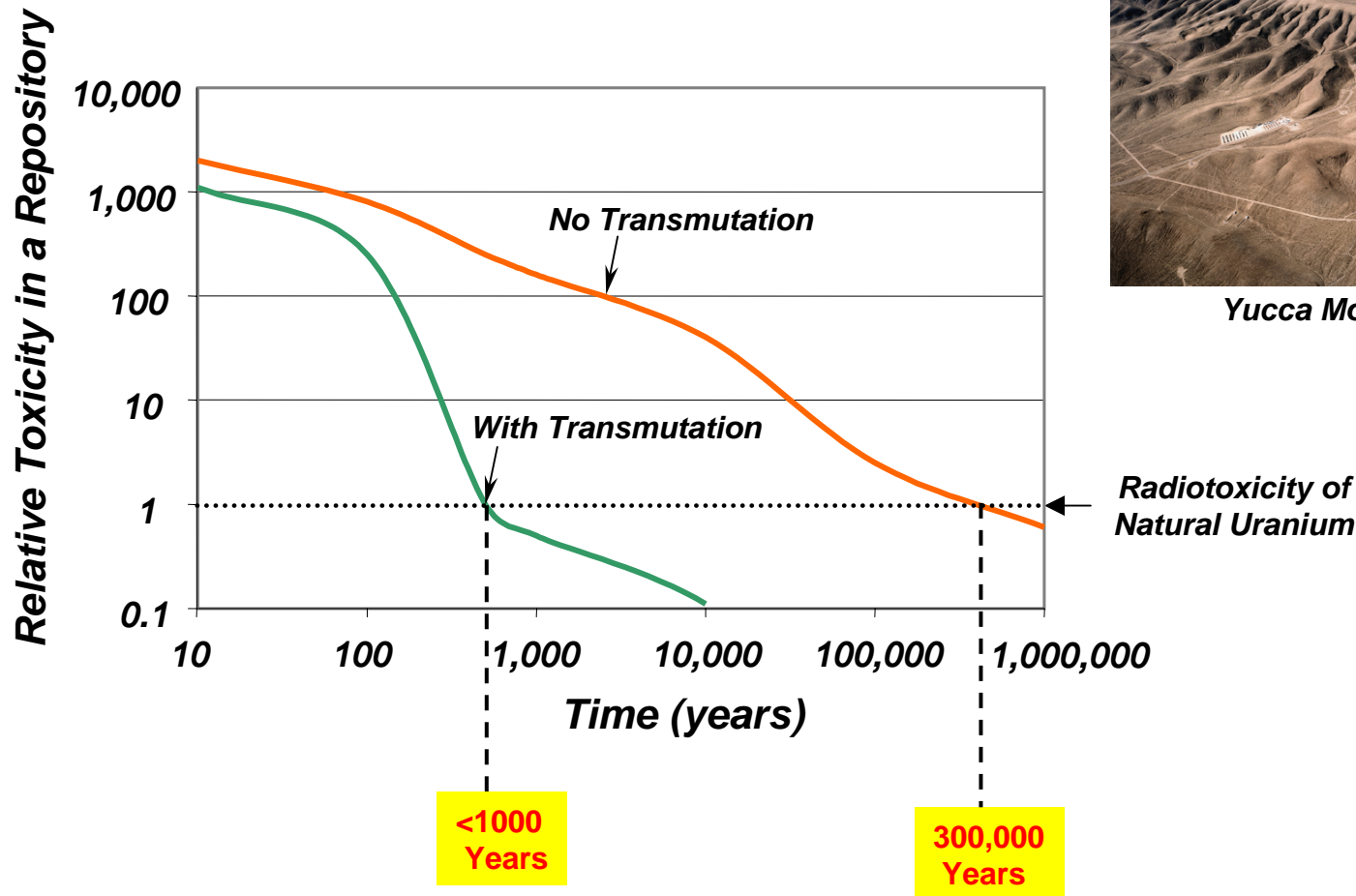
- ***Enables recovery of the energy value from commercial spent nuclear fuel,***
- ***Reduces the inventories of civilian plutonium in the U.S.,***
- ***Reduces the toxicity of high-level nuclear waste bound for geologic disposal, and***
- ***Enables more effective use of the currently proposed geologic repository and reduce the cost of geologic disposal***

January, 2003



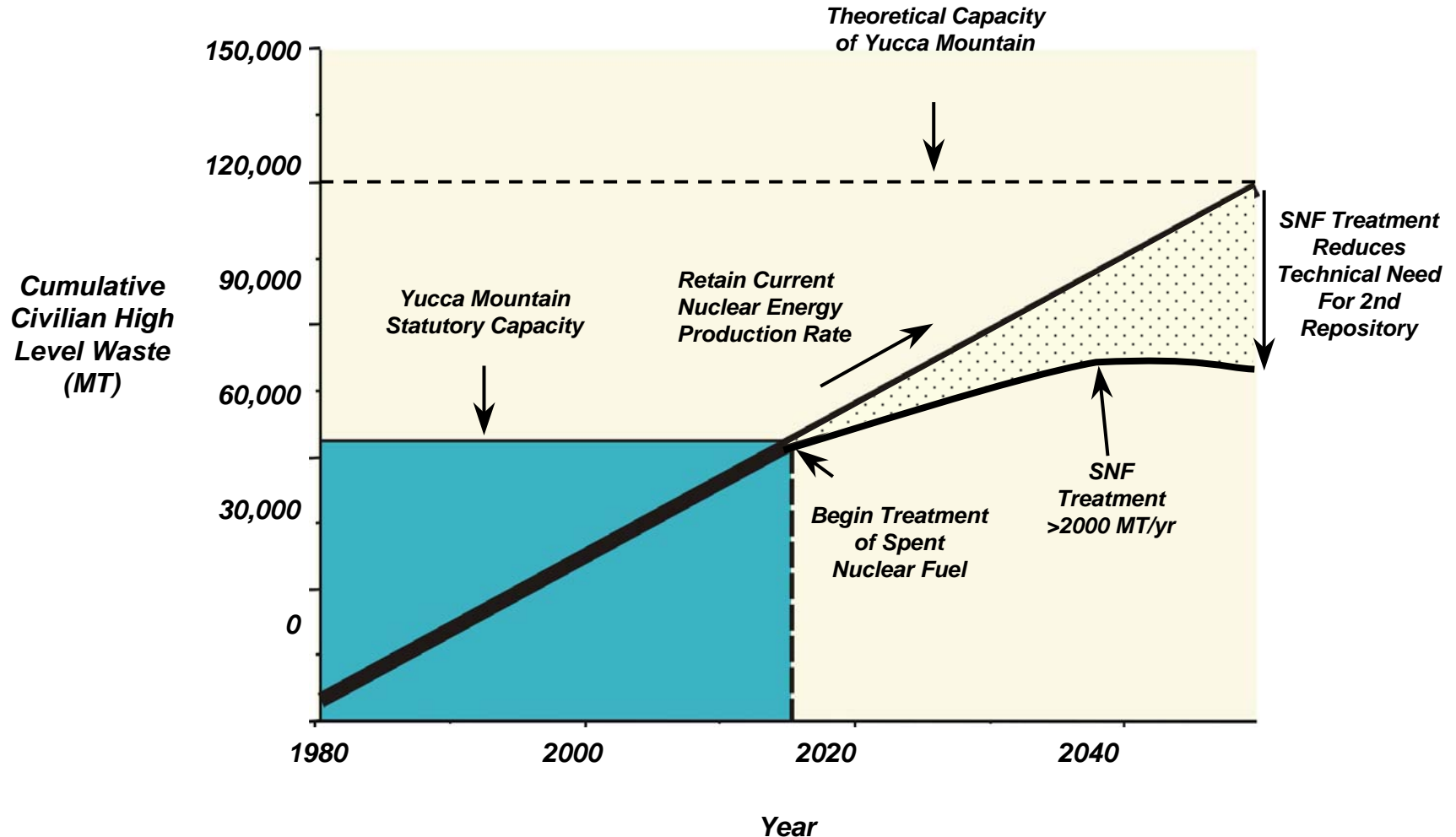
http://www.nuclear.gov/AFCI_RptCong2003.pdf

Radiotoxicity Reduction with Transmutation

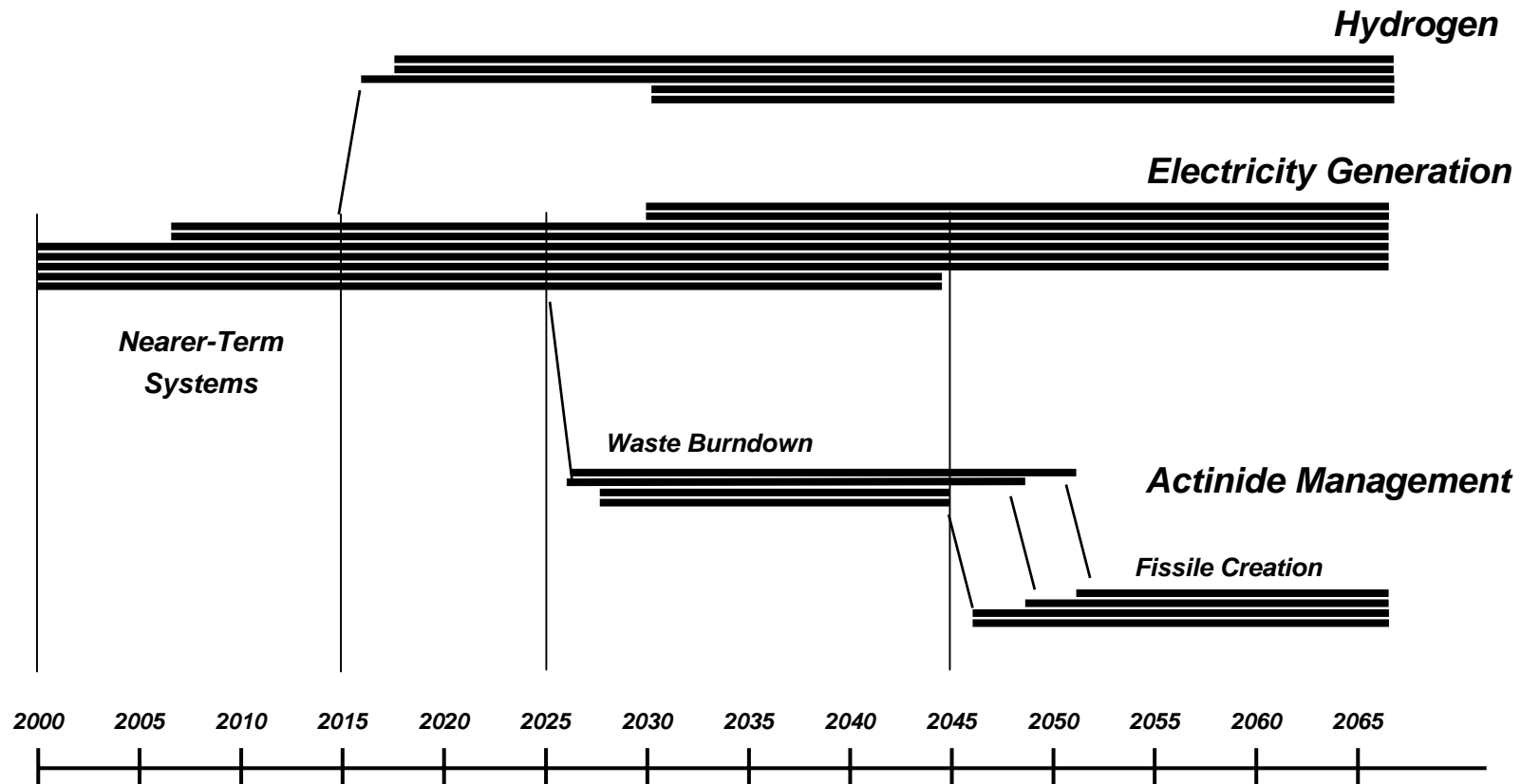


Yucca Mountain Repository

Benefit of Spent Nuclear Fuel Treatment

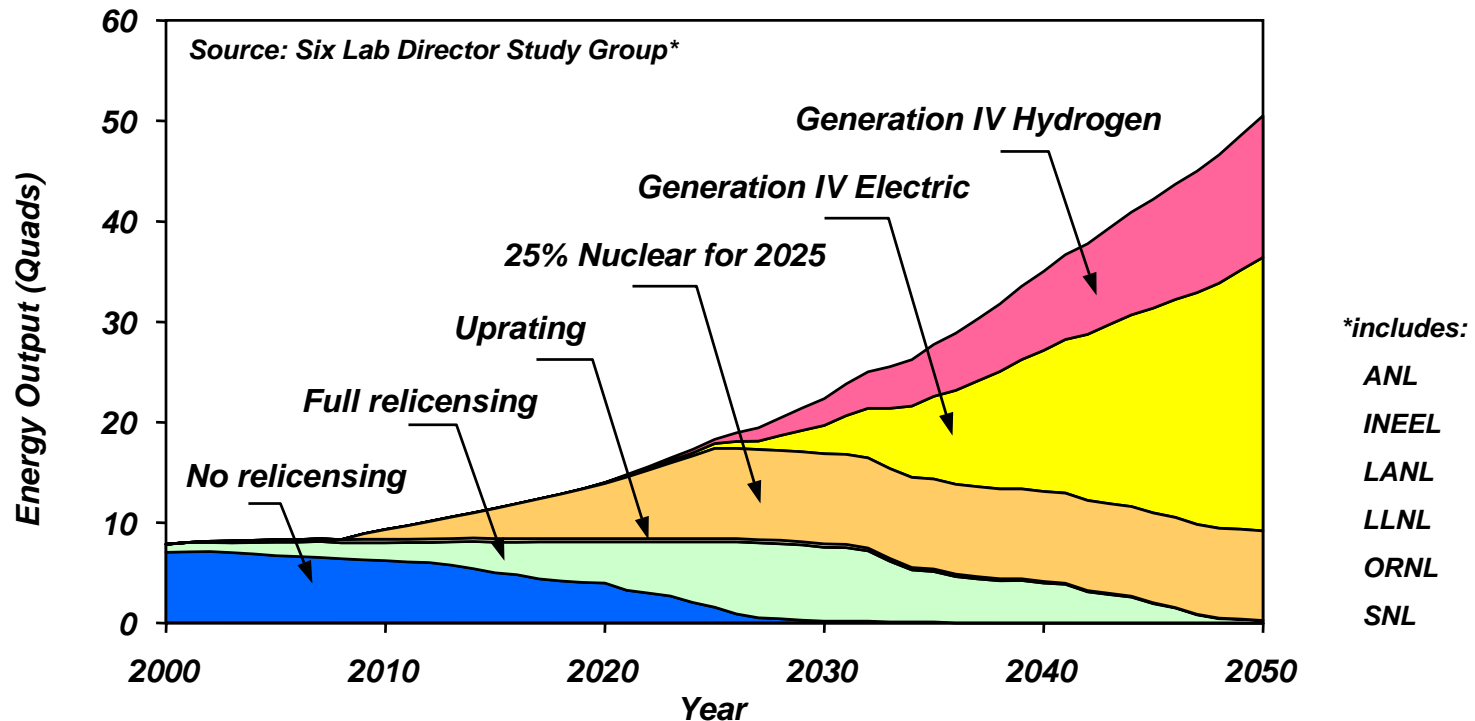


Important Missions for Generation IV



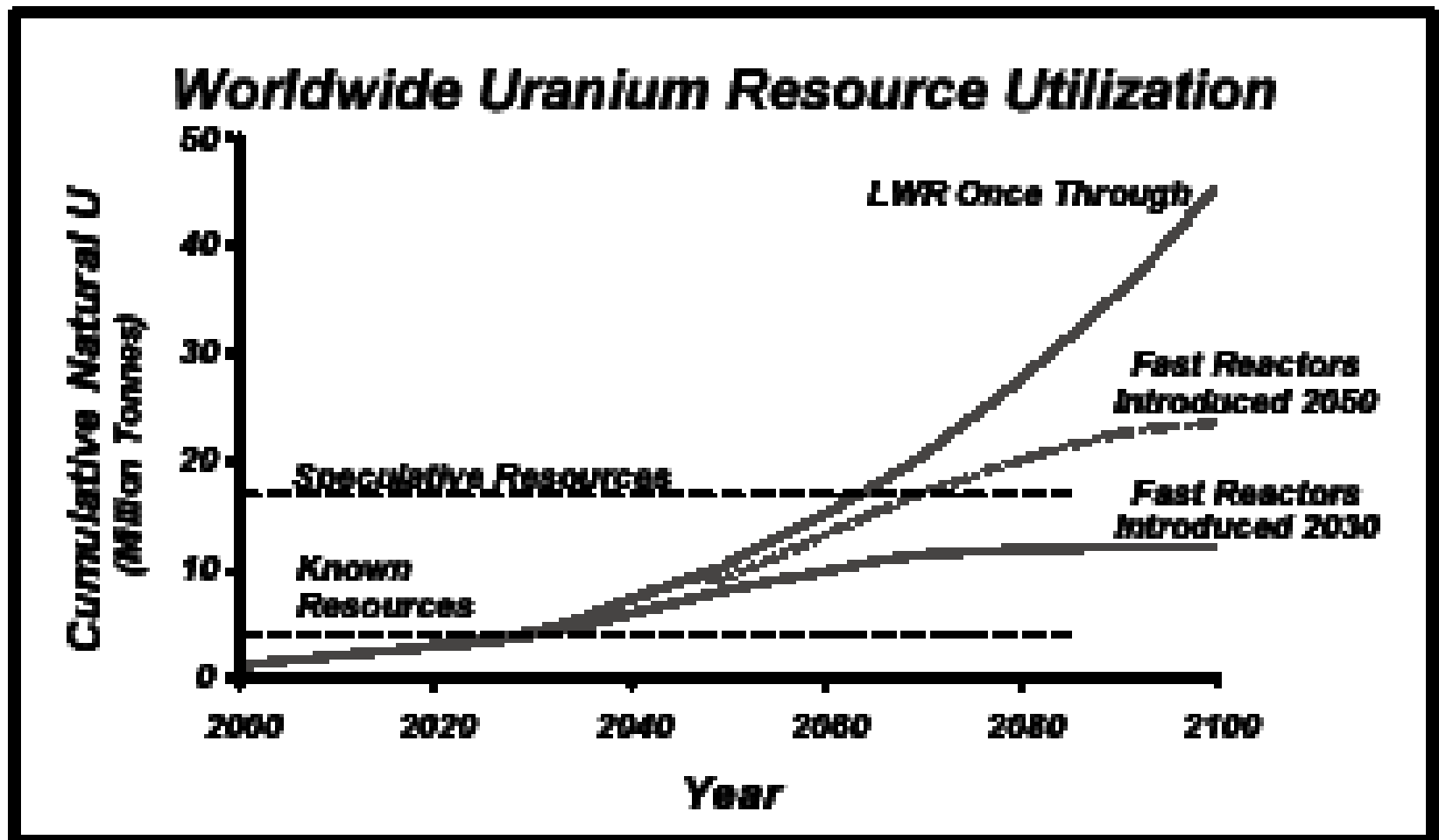
Expansion of the Nuclear Energy Supply

Nuclear Generation Scenarios



By 2050, with robust technology development:

- **50% of U.S. electricity production could be nuclear**
- **25% of U.S. transportation could use hydrogen from nuclear energy**



Summary and Implications for the Future

- *Economics, operating performance and safety of U.S. nuclear power are excellent*
- *Nuclear power is already a substantial contributor to reducing CO₂ emissions*
- *Nuclear power can grow in the future if it can respond to the following challenges:*
 - *remain economically competitive*
 - *retain public confidence in safety*
 - *manage nuclear wastes and spent fuel*
- *Nuclear power's impact on U.S. energy security and CO₂ emissions reduction can increase substantially with increased electricity production and new missions (hydrogen production for transportation fuel)*
- *The DOE Generation IV program and Advanced Fuel Cycle Initiative are addressing next generation nuclear energy systems for hydrogen, waste management, and electricity*

